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December 2006

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### Recommended Citation

Ginsburg, Mark, "Interface Considerations in a Web-Based Pediatric Electronic Medical Records System" (2006). *AMCIS 2006 Proceedings*. 321.  
<http://aisel.aisnet.org/amcis2006/321>

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# Interface Considerations in a Web-Based Pediatric Electronic Medical Records System

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## ABSTRACT

The development of private practice Electronic Medical Records (EMR) systems are being driven by economic impetuses (to reduce health care costs), ethical ones (to improve patient care by reducing errors) and social ones (to fit into the US Federal mandate of a planned National Health Information Network (NHIN)). This research-in-progress details the design and implementation of a Pediatric Web-based EMR System, PedOne™ with particular attention paid to the major aspects of its user interface experience. Parallels are drawn between the ideal attributes the hypothetical NHIN strives to achieve and the design goals of PedOne™.

## Keywords

Electronic Medical Records, Interfaces, Pediatrics, Design, Standards, National Health Information Network (NHIN)

## INTRODUCTION

The medical profession private practice and information technology (IT) has never seemed a good match. Despite numerous articles detailing the cost of antiquated IT (e.g. Baker 2004a), efforts have been sporadic. Although the benefits of Electronic Medical Records (EMR) systems are self-evident (such as reduced error rate in diagnosis and procedure coding, and a more reliable longitudinal patient history), and doctors have expressed interest (Baker 2004b), adoption in the private sector remains small (Baker 2005). Recently, US Government policy statements have prioritized a national healthcare information network (NHIN). The President's State of the Union Address (Anonymous, 2006) explicitly mentions nationwide electronic health records as a tangible goal. The IEEE (Institute of Electrical and Electronics Engineers) Medical Technology and Policy Committee (MTPC) have issued a position paper and white paper (Anonymous, 2005; Jepsen et al., 2006) detailing the major functional attributes of the proposed NHIN. Interest is high and fledgling standards to meet the ambitious NHIN requirements are in flux (Mosquera, 2006; Bell, 2005; Broder, 2006; Lawrence, 2006). In this research-in-progress, we present a private practice EMR system, PedOne™, that meets several of the stated NHIN goals and discuss its interface considerations.

## THE PEDONE SYSTEM BASICS

PedOne™ is a three-tier architecture web-based system for the doctors, nurses, and staff in a small private pediatric practice in use since November 2005. It uses the MySQL database on the back-end with the Red Hat Enterprise Linux operating system, Perl and JavaScript, and HTML with Cascading Style Sheets (CSS) to provide a consistent look and feel across the pages. The practice accesses the server with a variety of wired and wireless tablets, laptops, and desktops, running Windows XP. Many of the users prefer the Mozilla Firefox web browser for its tabbed interface feature; however no particular web browser is required (the system is 'agnostic' across operation systems and browsers). The interface philosophy borrows heavily from the efforts of Eric Meyer and Jeffrey Zeldman (Meyer, 2003; Zeldman, 2003) touting the worth of open standards development. Separating the content from the presentation is a good design idea, easing maintenance and imparting distinctive and intuitive styles to such important things as system error messages and form instructions. In addition, avoiding the trap of proprietary technologies conforms with the NHIN emphasis on standards and interoperability (Jepsen et al., 2006).

Specific CSS and JavaScript tricks are taken from useful web standards sites; a selection of valuable resources is shown in Table 1. Just as NHIN is recommended to be built on "existing Internet standards" (Jepsen et al., 2006), so PedOne™ is based on standard XHTML and CSS and the industry open source database leader, MySQL. The JavaScript is harder to call a standard, but the Firefox implementation is closely aligned to the standard scripting language ECMAScript. PedOne™ is a Rapid Application Development (RAD) prototype that undergoes constant interface alteration based on dialog with the users.

Title	Maintained By	URL
Eric Meyer CSS	Eric Meyer	http://www.ericmeyeroncss.com/
A List Apart	Jeffrey Zeldman	http://www.alistapart.com/
Real World Style	Mark Newhouse	http://realworldstyle.com/

Table 1. Useful Web Standards Design Resources

## PEDONE WALKTHROUGH AND INTERFACE DISCUSSION

Using an amalgamation of CSS and JavaScript techniques culled from the sites listed in Table I, a clean layout was devised. It is a two-column, four-component layout. On the left, there is a navigation Menu and the user's role is clearly indicated (for example, a biller, or a scheduler, or the site administrator). The administrator has the ability to set up new user accounts and roles. At the top, there is a standard Header, on the left, the Menu, on the right, the Content, and on the bottom, the Footer. The introductory screen (after user login) is shown in Figure 1. The Footer is omitted to save space.

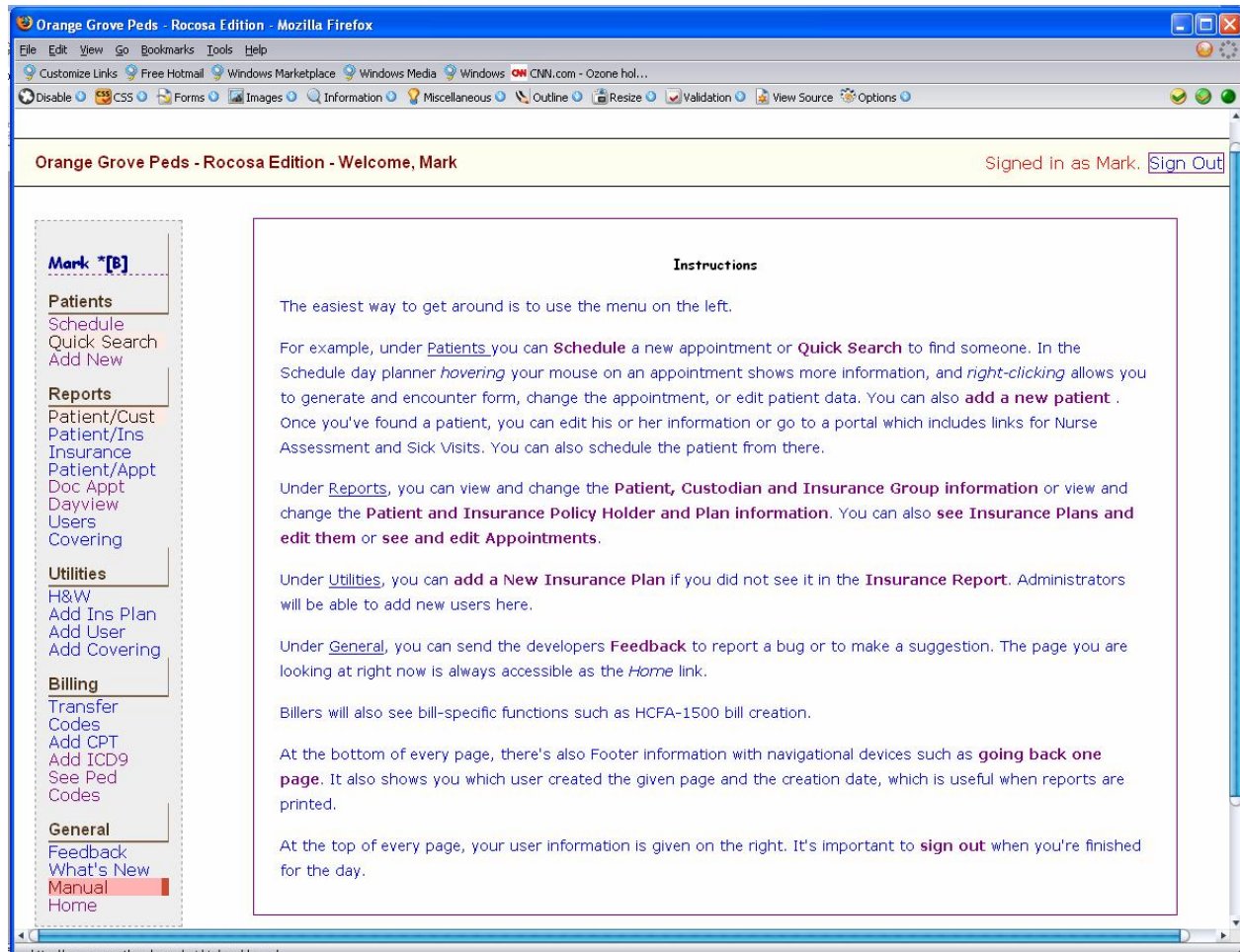


Figure 1. The PedOne Entry Screen

Figure 1 shows the basic geometry. CSS techniques provide highlighting of the left Menu entries on a mouse-hover event. CSS rules place border lines around system messages, such as the instruction box shown in the Content area. The user in this

case, 'Mark', has Billing Rights and Administrative Rights as indicated by the 'B' and the '\*' at the top of the Menu. The Menu is dynamic; adding and subtracting options depending on both user role and context. For example, if the user is positioned on a Patient Visit, the Menu will provide Billers with an additional option to format and print an insurance claim form (the HCFA-1500 form). The users mentioned as a key requirement clear role identification in the menu.

### Design Goals of PedOne

The IEEE MPTC E-Book (Jepsen et al., 2006) mentions functional and semantic interoperability as a key goal of the NHIN. They are also an important deliverable of PedOne™. The functional piece is trivial for electronic systems; it simply means recording form fields and retrieving them without error. The semantic portion is more challenging. Simply put, there are numerous coding standards that confront the practice staff. Two of the major code families are the ICD9 (International Classification of Diseases, 9<sup>th</sup> Revision) for diagnoses and Current Procedural Terminology (CPT) for procedures (exams, medications, supplies, treatments). These codes change over time, and are essential for patient record keeping, billing, and insurance claims submission. Semantic interoperability means the users have to successfully interpret the coded information in the system session. Only the code is necessary for billing and claims; but the description helps sense-making efforts during the data input. Thus it is important to give the users an easy way to edit code descriptors and have the new, simpler descriptors made immediately available in the online forms. Figure 2 shows an example of this (Menu, Header and Footer omitted to save space).



Code	Short Desc	Last Changed
<a href="#">V03.6</a>	Need for Pertussis Category: Imm	Mark 2006-02-27
<a href="#">V03.82</a>	Need for Prevnar Category: Imm	Mark 2006-02-27
<a href="#">V03.89</a>	Need for Hep B Vaccine Category: Imm	Mark 2006-02-27
<a href="#">V04.3</a>	Need for Rubella Category: Imm	Mark 2006-02-27
<a href="#">V04.6</a>	Need for Mumps Category: Imm	Mark 2006-02-27
<a href="#">V04.81</a>	Need for Flu Vaccine Category: Imm	Mark 2006-02-27
<a href="#">V05.3</a>	Need for Rotavirus Category: Imm	Mark 2006-02-27
<a href="#">V05.8</a>	Need for Hep A Vaccine Category: Imm	Mark 2006-02-27
<a href="#">V06.4</a>	Need for MMR Category: Imm	Mark 2006-02-27
<a href="#">V06.5</a>	Need for Decavac, Td/Dt Category: Imm	Mark 2006-02-27
<a href="#">V06.8</a>	Need for Comvax, DTaP, daptacel, infanrex Category: Imm	Mark 2006-02-27
<a href="#">V06.9</a>	Need for BPD	Mark 2006-02-27

**Figure 2. Friendlier ICD9 Descriptors**

If the user clicks on the code on the left column in Figure 2, an edit screen is brought up to change code descriptors. Similarly, the user can change CPT descriptors and add unit charges for CPT procedures. It is important to note that PedOne™ must provide an accurate longitudinal patient record (also a key goal of the NHIN) – thus if a code changes, the

old code must not be deleted and must instead be flagged as inactive. It is often important to go back to the moment of the diagnosis or procedure to resolve billing or patient history issues.

ICD9 and CPT codes are the backbone of many of the system functions. For example, to post a charge, the user needs to select up to four diagnoses and up to six procedures (these are the limits of a single claims submission form; if the limits are exceeded multiple claims are produced). The interface becomes busy and techniques were devised to make it as easy as possible for the biller to work his or her way through the screen. Figure 3 shows the basic charge posting screen.

**Orange Grove Peds - Rocosa Edition - Mozilla Firefox**

File Edit View Go Bookmarks Tools Help

Customize Links Free Hotmail Windows Marketplace Windows Media Windows CNN.com - Ozone hol...

Disable CSS Forms Images Information Miscellaneous Outline Resize Validation View Source Options

**Mark \*[8]**

**Patients**  
Schedule  
Quick Search  
Sick Visit  
Edit Current  
Portal  
Add New

**Reports**  
Patient/Cust  
Patient/Ins  
Insurance  
Patient/Appt  
Doc Appt  
Dayview  
Users  
Covering

**Utilities**  
H&W  
Add Ins Plan  
Add User  
Add Covering

**Billing**  
Transfer  
Codes  
Add CPT  
Add ICD9  
See Ped  
Codes  
HCFA Bill

**General**  
Feedback  
What's New  
Manual  
Home

**Patient Charge Post Screen: Jon Test [Age: Y:12 M:1 ]**

Instructions: Enter the Procedures performed (up to 6), POS and D/U for the Procedures. Also enter any co-pay received for the procedures. Then hit the Post Charges button at the bottom of the screen. There is a link provided to [edit CPT unit charges](#) if you need to adjust that beforehand. The system will enter the charges into the database.

**Basic Info**  
Doctor: Nurse Practitioner (NP) Service Date: 02/21/2006  
Visit Type: Well Visit Covering:  
Notes: test Contact:

**ICD9 Diagnoses**  
[Imm] [Injuries] [Insect Bites]  
[Lacerations] [Nevus]  
[Add New]

599.0:UTI  
079.99:Viral Syndrome  
783.1:Weight Gain  
783.21:Weight Loss  
V70.0:Well Adult  
V20.2:Well Child [Clear Diag]

V06.8:Need for Convax, DTaP, dectacel, infanre  
V06.5:Need for Decavac, Td/Dt  
V04.81:Need for Flu Vaccine  
V05.8:Need for Hep A Vaccine  
V03.89:Need for Hep B Vaccine  
V06.4:Need for MMR [Clear diag] [Edit icd9 Imm]

892.0:Laceration Foot  
873.42:Laceration Forehead  
873.43:Laceration, Chin  
873.49:Laceration, earlobe  
881.01:Laceration, elbow  
870.8:Laceration, eyelid

216.6:Nevus, Arm and Shoulder, benign  
239.2:Nevus, Cheek, Uncertain behavior  
216.5:Nevus, chest benign  
216.7:Nevus, leg, benign  
448.1:Nevus, nonneoplastic  
236.6:Nevus, scrotum, uncertain behavior

**DiagCode**  
**DiagDesc**

D1	D2	D3	D4
V04.81	873.43		
Need for Flu Vaccine	Laceration, Chin		

February, 2006  
Today  
wk Sun Mon Tue Wed Thu Fri Sat  
4 5 6 7 8 9 10 11  
6 12 13 14 15 16 17 18  
7 19 20 21 22 23 24 25  
8 26 27 28  
Select date

Figure 3. Charge Posting Screen.

Figure 3 shows a cascading set of “DIV” elements as defined in the CSS global style rules. The user can toggle them (hide or show) by clicking on the links which are in square brackets, such as [Imm] for Immunization diagnoses, Injuries, Insect Bites, and so on. Segregating the codes into categories has several advantages. Many of the code sets are used only infrequently, such as Insect bite. If we put all the codes into one list, the user would have to struggle with the mouse and the scroll-bar. Another advantage is we can provide specific functions for each category. Thus the [Edit icd9 Imm] link shows only Immunization-specific ICD9 codes for editing akin to Figure 2. Figure 3 also shows the handy calendar widget on the upper right. As the user picks from the category lists, items are transferred into the slots which are shown at the bottom of Figure 3. This user screen also includes CPT codes, similarly grouped, which populate 6 slots (not shown for space reasons). When the ICD9 or CPT slots are filled, the Javascript alerts the user and provides a link to clear them and start over. The goal here is to reduce the “cost structure of information” (Card, Mackinlay, and Shneiderman, 1999) by pre-populating fields as much as possible and hiding little-used fields. The net effect is faster data throughput to the internal accounting system, freeing the biller for other tasks.



## Scheduling Patient Visits

One of the most important modules is the Scheduler. In this screen, the doctors are organized by column in the Content section, and patient visit types are represented by various intuitive icons. Simple self-documenting icons were created and approved by the users. For example, a well-visit is shown by a heart icon and a sick visit is a patient with an IV bottle. A sample day is shown in Figure 4.

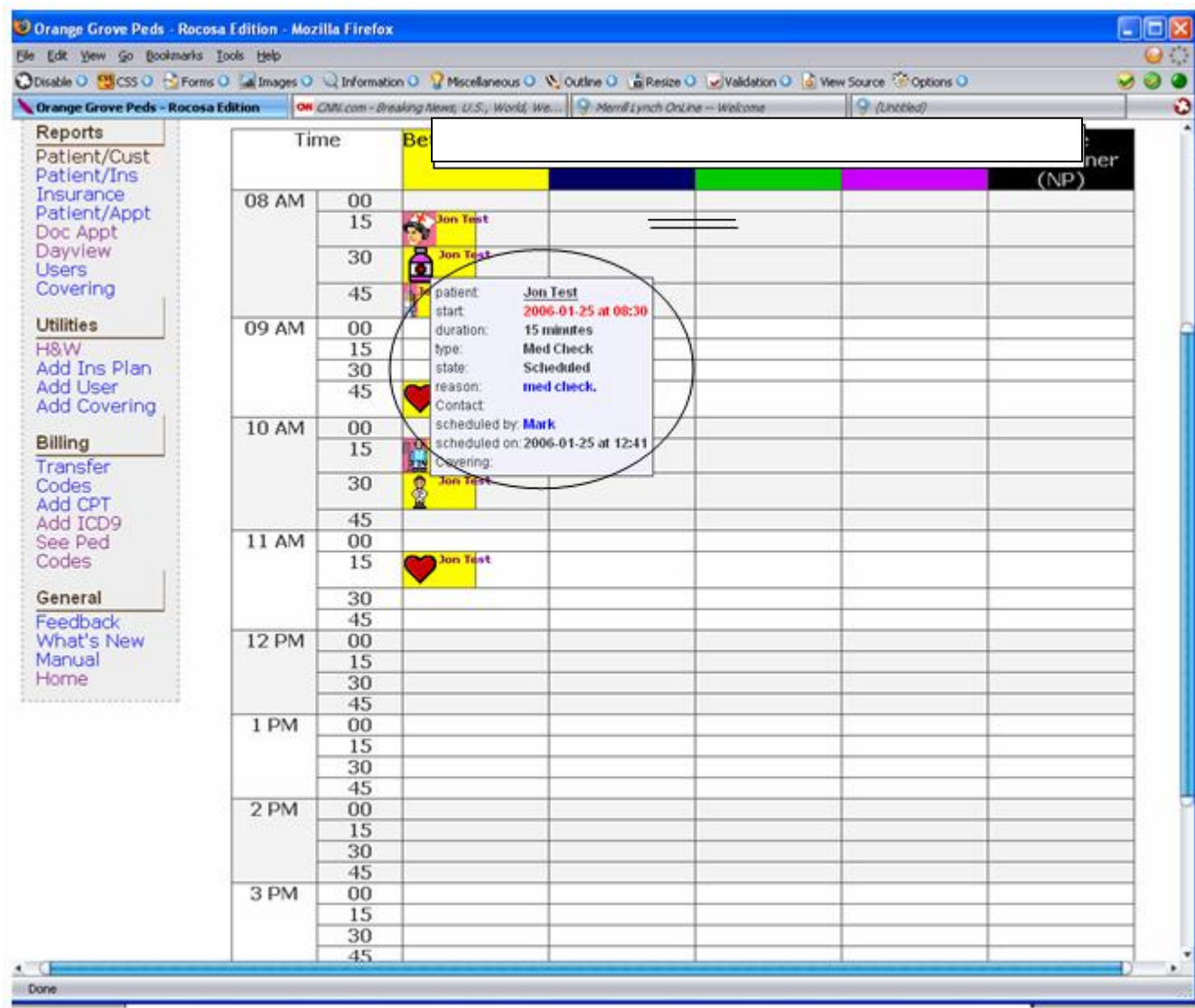










Figure 4. The Scheduler Day View.

Figure 4 also shows a mouse-hover event (circled) on a certain appointment. Metadata about the appointment is displayed, such as the date and time it was made, contact information, and the staff ID who created the record. In this case, the mouse is hovered on a visit type of Medication Check and the icon is a pill bottle. The screen region to bring up the metadata is fairly large; it is the rectangular size of the appointment (in 15 minute units). Another set of actions is available on right-click (implemented with a JavaScript context menu). An excerpt of the right-click action is shown in Figure 5.

Figure 5 shows that right-clicking gives the users a chance to edit (change its date and time, using the familiar calendar widget), delete it altogether (placing the user at the same page, minus that appointment) or generate an encounter form.

M	00				
	15	 Jon Test			
	30	 Jon Test			
	45	 Jon Test			
M	00				
	15				
	30				
	45	 Jon Test			
M	00				
	15	 Jon Test			
	30	 Jon Test			
	45				
M	00				
	15	 Jon Test			
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	15	 Jon Test			
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In Figure 6, the “Test” entry fetches all patients whose names start with Test. Two actual patient names and the primary care physician are blanked out for anonymity. The completions are placed in an inline XHTML element called an ‘IFrame’. This is a very useful interface technique, but one must be careful with long auto-complete lists. They may shift or obscure the standard Content and Footer components. Also shown in this Figure is a standard CSS-defined Instruction box. Color rules are used to simplify the user help display. Another interface consideration is to daisy-chain likely event sequences. Thus ‘Schedule’ (to make an appointment) and ‘Edit’ (to change patient or custodian information) are both hyperlinks in the auto-completion list.

### The Doctor Sick-Visit Interview

The authors worked closely with the doctors to design a sick-visit interview form. It is highly tailored to pediatric practice, with domain specific prescription ‘hints’ (for example, dosage per kilogram) and other granular input areas. An excerpt of the sick-visit form is shown in Figure 7.

	Rx1	Rx2	Rx3	Rx4
Med	Cefzil 500mg	Cefzil 250mg/5cc	Cimetidine 300mg/5cc	
Amt	1 pill			
#/day	po BID	po BID	po BID	
# days	x10days	x10days		
qty	2	1		

**Figure 7. The Doctor Sick-Visit Interview.**

Figure 7 shows part of the lengthy form. JavaScript is used to colorize the focused field – the interface consideration is to help the users in a long form with location cues. In this case, the user is positioned on the NEURO comment box and it is yellow. The Rx List is analogous to the ICD9 and CPT lists we saw earlier. The doctor can peruse the template and populate up to 4 Rx slots, or clear them out if an error was made.



## CONCLUDING REMARKS

In this quick tour of the PedOne™<sup>1</sup> system, we have illustrated some of the major functional modules and discussed how the interface considerations dovetail with recommendations set forth for the National Health Information Network. This commonality is logical since private practice EHR systems are part of the NHIN architecture (as are hospitals, insurance carriers, and the patient community). We have also shown how PedOne™'s reliance on open web standards has simplified much of the interface design

## ACKNOWLEDGMENTS

We thank the staff of Orange Grove Pediatrics for giving us unlimited access to the doctor, nurse, and front-office staff for system iteration.

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